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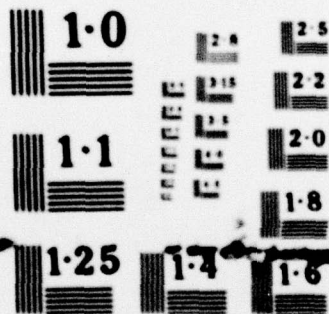
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LABORATORY OBSERVATIONS ON THE BEHAVIOR OF
COMPOSITE DENTAL RESTORATIVES

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Commercial materials and equipment are identified in this report to specify the experimental procedure. Such identification does not imply official recommendation or endorsement or that the equipment and materials are necessarily the best available for the purpose.

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LABORATORY OBSERVATIONS ON THE BEHAVIOR OF
COMPOSITE DENTAL RESTORATIVES

Over the past ten years, composite restoratives have been used extensively in military dental practice for the direct and esthetic restoration of anterior teeth. Conventional composites, for the most part, consist of an organic (Bis-GMA resin) matrix and an inorganic (quartz, borosilicate, barium glass or strontium glass) filler. The size of the filler particles employed in the formulation of most available composites ranges from 5 to 100 μm . Recently, however, silica particles of colloidal dimensions ($<1 \mu\text{m}$) and finely powdered resins have been used as filler components in the manufacture of so-called microfilled composites.

The present laboratory investigation was conducted to build a reliable data base for comparative evaluation of conventional and micro-filled composite restoratives.

Materials and Methods

Composite restoratives bearing trade names of Isopast^{*} Superfil⁺ and Profile[#] were obtained through the open commercial market.

- * Microfilled composite: Vivadent, Schaan, Liechtenstein.
- + Microfilled composite: H. J. Bosworth Co., Skokie, IL 60076.
- # Conventional strontium glass containing composite: S. S. White Dental Products International, Philadelphia, PA 19102.

Proportioning and mixing of the two paste components of each material were accomplished as directed by manufacturer's instructions. The resultant mixtures were packed into steel molds for the fabrication of test specimens. Unless indicated otherwise, the specimens were cured for 24 hours at 37°C and 100 per cent relative humidity prior to removal from their respective molds and subjection to testing.

Specimens for measurement of polymerization shrinkage and compressive strength were obtained from 1/4 in X 1/2 in cylindrical molds. Discs of 1/4-inch diameter and 1/16-in thickness were used for determination of tensile (diametral compressive) strength. Cylindrical 1/4-in X 1/4-in pieces were made for assessment of thermal behavior. Polymerized 4-gram masses of irregular geometry were used for determination of the organic-inorganic weight ratio of each test product. Specimens prepared for measurement of solubility and disintegration and water sorption consisted of 1-in X 1/16-in discs.

Volumes of 24-hour old cylindrical specimens were measured by water displacement for determination of polymerization (curing) shrinkage. Shrinkage was calculated as a percentage of the known volume of the mold employed in specimen preparation.

Compressive and tensile strengths were measured on a constant strain-rate testing machine[§] at a crosshead speed of 0.02 in per minute. Elastic limit values were established from load tracings obtained on compression testing.

§ Instron Universal Testing Machine, Instron Corp., Canton, MA 02021.

Dimensional changes induced by heating of the composites over a temperature range of 20 to 40°C were monitored with the use of a thermal mechanical analyzer.[¶] Heating of the test pieces was accomplished at a nominal rate of 5°C per minute. The experimental procedure was further tailored to yield continuous plots of temperature versus linear displacement of the instrument's quartz probe. The graphic records made possible the derivation of linear coefficients of thermal expansion.

For determination of organic-inorganic weight ratio, cured samples of each material were ashed in ceramic crucibles for 72 hours at 430°C. The crucibles were cooled to room temperature and stored in a desiccator over silica gel until constant weight of the residual matter was attained. Quantitative determination of the total volatile (organic) component of each product was based on weight loss resulting from pyrolysis.

Water sorption as well as solubility and disintegration specimens were cured at 37°C and 100 per cent relative humidity for 15 minutes prior to deflasking. The deflasked discs were dried in a desiccator over anhydrous calcium chloride at 37°C for 24 hours, removed to a similar desiccator at 23°C for 1 hour, and then weighed. The desiccation cycle was repeated until the weight loss of each disc was not greater than 0.5 mg in any 24-hour period. Measurement of water sorption was accomplished as prescribed by American Dental Association Specification No. 27 for Direct Filling Resins.¹ Procedures employed in determination of solubility and disintegration were those prescribed by American Dental Association Specification No. 9 for Dental Silicate Cement.²

¶ TMS-1, The Perkin-Elmer Corp., Norwalk, CT 06856

Results

Data from the laboratory tests are summarized in the table. Mean values for strength properties and linear coefficient of thermal expansion are based on a minimum of six measurements. Other tabular data are average values obtained from duplicate trials.

Discussion

The laboratory findings reflect a potential for wide variation in the clinical performance capabilities of proprietary composite restoratives. The disparate patterns of behavior exhibited by Isopast and Superfil on one hand, and by Profile on the other hand, are attributed to extreme compositional differences. The relatively high polymerization shrinkage, water sorption and thermal expansion of Isopast and Superfil are manifestations of high resin content. Conversely, suppression of the aforementioned properties is accomplished by the high inorganic filler content of Profile.

Although the ultimate strengths of the three test products are comparable, the overall mechanical performance potential of the resin-rich materials (Isopast and Superfil) is compromised by severe plastic deformation which accompanies loading in the compressive and tensile modes. The tendency for these materials to deform plastically (permanently) under relatively low loads is evidenced by exceedingly low values for elastic limit.

Clinical experience has indicated that Isopast and Superfil restorations can be contoured, surface-finished and polished with relative ease. However, the advantage afforded by apparent smooth surface texture

may be overshadowed by the increased probability of excessive sorption of oral fluids with concomitant swelling and discoloration, continuous marginal percolation and inadequate ability to withstand masticatory forces.

Summary and Conclusions

Several properties of three composite dental restorative materials were determined. The overall behavior of two microfilled materials exhibiting organic-inorganic weight ratios in excess of 1.0 was inferior to that of a single product containing significantly less organic matter. The routine clinical application of materials of the former type as alternatives to composites of more conventional composition (inorganic filler content ≥ 70 per cent by weight) is not warranted.

References

1. Council on Dental Materials and Devices, New American Dental Association Specification for Direct Filling Resins, JADA 94(6): 1191-1194, 1977.
2. Guide to Dental Materials and Devices, ed 7. Chicago, American Dental Association, Council on Dental Materials and Devices, 1974, pp 194-198.

APPARENT PROPERTIES OF COMPOSITE RESTORATIVES

Property	Isopast	Superfil	Profile
Organic-Inorganic Weight Ratio	1.70	1.94	0.28
Compressive Strength, 10^3 psi	40.1 (8.3)*	32.2 (6.4)*	31.5 (2.4)*
Elastic Limit, 10^3 psi	8.3 (0.51)*	7.7 (1.1)*	19.0 (0.7)*
Tensile Strength, 10^3 psi	4.2 (0.4)*	4.5 (0.2)*	4.7 (0.5)*
Polymerization Shrinkage, %	3.8	1.3	Nil
Water Sorption, mg/cm ²	1.40	2.30	0.50
Solubility and Disintegration, %	0.30	0.20	0.15
Linear Coefficient of Thermal Expansion (20-40°C), $10^{-6}/^{\circ}\text{C}$	60.6 (2.8)*	59.1 (4.5)*	24.2 (0.4)*

* Mean value with standard deviation in parentheses.